# National Transportation Safety Board

Washington, D.C. 20594

## Safety Recommendation

**Date:** April 14, 2009

**In reply refer to:** A-09-38 through -40

Mr. James Thomas
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The National Transportation Safety Board is an independent Federal agency charged by Congress with investigating transportation accidents, determining their probable cause, and making recommendations to prevent similar accidents from occurring. We are providing the following information to urge your organization to take action on the safety recommendations in this letter. The Safety Board is vitally interested in these recommendations because they are designed to prevent accidents and save lives.

These recommendations address ASTM International standards that are used for designing Special Light Sport Aircraft (S-LSA). The recommendations are derived from the Safety Board's investigation of a series of in-flight structural breakups of Zodiac CH-601XL airplanes designed by Zenair, Inc., that occurred in the United States during the last 3 years and are consistent with the evidence found and the analysis performed. As a result of this investigation, the Safety Board has issued 11 safety recommendations, 3 of which are addressed to ASTM International. Information supporting the recommendations is discussed below. The Safety Board would appreciate a response from you within 90 days addressing the actions you have taken or intend to take to implement our recommendations.

The Safety Board's investigation has found that aerodynamic flutter is the likely source of four of the U.S. accidents involving CH-601XL and of at least two foreign accidents. Two of the accident airplanes were classified as S-LSA. S-LSA are designed to consensus industry standards developed by ASTM International's Committee F37 on Light Sport Aircraft and presented in ASTM F-2245 "Standard Specification for Design and Performance of a Light Sport Airplane." The Board's investigation has identified several areas in which the ASTM standards could be improved to enhance safety, and this letter asks ASTM to take action in those areas.

Aircraft Manufacturing & Development Company (AMD), based in Eastman, Georgia, manufactured one of the S-LSA accident airplanes. Czech Aircraft Works (CZAW), based at Konovice Airport, Czech Republic, manufactured the other. The two other accident airplanes were classified as experimental amateur built airplanes, which were constructed from kits. The kits were supplied by Zenith Aircraft, based in Mexico, Missouri, and assembled by individual builders. The Safety Board is also aware of two additional in-flight breakups of CH-601XL airplanes that occurred in Spain and the Netherlands, in which flutter was apparently a factor. Further, several pilots have reported experiencing flutter in the CH-601XL. The structural design of all the accident airplanes is essentially the same.[1]

**Accidents**

On February 8, 2006, about 1515 Pacific standard time, a CH-601XL airplane, N105RH, crashed into terrain near Oakdale, California, after its wings collapsed as the airplane entered the traffic pattern of the nearby airport.[2] The pilot, who was a certified flight instructor, and a student[3] were killed, and the airplane was destroyed by postcrash fire. The airplane was classified as an experimental amateur-built airplane and was operating under the provisions 14 *Code of Federal Regulations* (CFR) Part 91 as an instructional flight. Visual meteorological conditions prevailed.

A witness reported hearing the engine "rev up" while the airplane was flying between 800 and 1,000 feet above ground level (agl). The witness saw the wings "visibly vibrate" and then saw the left wing collapse and fold rearward against the fuselage. The witness stated that the airplane then pitched down and spun to the right and that the right wing collapsed upward and folded against the fuselage.

Although the airplane was consumed by fire, the Safety Board was able to determine that the wings failed because of overload and that the probable cause of the accident was the structural failure of the wings for undetermined reasons.

On November 4, 2006, about 1139 Pacific standard time, a CH-601XL airplane, N158MD, broke up in flight while cruising near Yuba City, California.[4] The pilot and passenger were killed, and the airplane was destroyed. The airplane was classified as an S-LSA and was operating under the provisions 14 CFR Part 91 as a personal flight. Visual meteorological conditions prevailed.

Surveillance radar shows the airplane in steady-level flight about 2,600 feet agl at about 106 knots ground speed. The airplane entered a climb of about 700 feet per minute to 2,800 feet agl and subsequently began a rapid descent.[5] The breakup sequence began with a downward separation of the horizontal stabilizer from its fuselage attachments due to overload, followed by downward overload and separation of the wings. The Safety Board determined that the probable

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[1] There are two versions of aileron design for the experimental CH-601XLs. One type uses piano hinges, and the other uses flexible skins that allow aileron motion.

[2] Additional information about this accident, LAX06LA105, can be found on the Safety Board's website at <http://www.ntsb.gov/ntsb/brief.asp?ev_id=20060217X00209&key=1>.

[3] The student held a private pilot certificate with an airplane single-engine land rating. He was receiving a checkride in the accident airplane.

[4] Additional information about this accident, LAX07FA026, can be found on the Safety Board's website at <http://www.ntsb.gov/ntsb/brief.asp?ev_id=20061115X01677&key=1>.

[5] Altitude information was transmitted by the airplane's mode C transponder to a ground-based facility.

cause of the accident was an in-flight structural failure of the horizontal stabilizer and wings for undetermined reasons.

On February 5, 2008, a CH-601XL airplane, EC-ZMJ, built by the pilot collided with terrain near Barcelona, Spain, after its wings folded up during a descent shortly before landing. The pilot and passenger were killed. Daylight and clear weather conditions prevailed. Witnesses reported that the right wing folded over the left wing above the airplane. Some witnesses observed the wings vibrate prior to folding. This accident is still under investigation.

On April 7, 2008, about 1701 eastern standard time, a CH-601XL airplane, N357DT, broke up in flight near Polk City, Florida.[6] The pilot was killed, and the airplane was substantially damaged. The airplane was classified as an S-LSA and was operating under the provisions of 14 CFR Part 91 as a personal flight. Visual meteorological conditions prevailed. A witness on the ground observed the airplane as it approached him and noted that it was banked slightly left. The airplane then banked slightly right and then banked to the left and right again at significantly steeper angles. Shortly after, the airplane suddenly yawed right and, according to the witness, "the right wing folded up." About this time, the witness heard the engine's pitch change as the airplane entered a nose-down descent. Another witness reported hearing a "pop" sound and observing the right wing folded back and to the side while the airplane descended. The investigation of this accident is ongoing.

On September 14, 2008, about 1240 local time, a CH-601XL airplane, built by the pilot from a kit manufactured by CZAW, crashed in the Netherlands. The pilot and passenger were killed, and the airplane was destroyed. Witnesses reported that the airplane was in level flight at approximately 1,000 feet agl when the right wing folded up over the fuselage. The airplane entered a steep dive and impacted a lake. Visual meteorological conditions prevailed. This accident is still under investigation.

On March 3, 2009, about 0838 mountain standard time, a CH-601XL airplane, N3683X, broke up in flight while cruising near Antelope Island, Utah.[7] The commercial pilot was killed, and the airplane was destroyed. The airplane was classified as an experimental amateur-built airplane and was operating under the provisions of 14 CFR Part 91 as a personal flight. Visual meteorological conditions prevailed.

The flight originated from Tooele, Utah, approximately 10 minutes prior to the accident. Surveillance radar shows the airplane in steady flight traveling north (altitude not reported) at about 112 knots calibrated airspeed (KCAS). Prevailing wind was generally from the south at about 14 knots, gusting to 20 knots. Turbulence was reported in the area at the time of the accident. There are no known observers of the accident.

The investigation of the Antelope Island, Utah, accident is ongoing. However, preliminary examination of the wreckage indicates that the breakup sequence began with the

[6] Additional information about this accident, NYC08FA158, can be found on the Safety Board's website at <http://www.ntsb.gov/ntsb/brief.asp?ev_id=20080421X00519&key=1>.

[7] Additional information about this accident, WPR09FA141, can be found on the Safety Board's website at <http://www.ntsb.gov/ntsb/brief.asp?ev_id=20090304X63009&key=1>.

buckling up of the upper spar cap of the left wing followed by the wing folding up and over the fuselage. The buckling is similar to a failure observed during structural tests of a CH-601XL wing performed in the Czech Republic by CZAW for certification purposes.[8] Many of the features and characteristics of the breakup at Antelope Island are similar to the other accidents discussed above. The builder stated that the airplane had accumulated about 14 hours of flight at the time of the accident. He stated that before the first flight, the tensions of the control cables were set according to the instructions provided by Zenair and that the cable tensions were checked again at 8 flight hours (6 flight hours before the accident flight) and had not changed. This is significant because, as discussed later, the designer has asserted that maintaining adequate cable tension provides sufficient protection against flutter.

**Wing Structure Strength**

Wing structure is always a concern when an airplane breaks up in flight. Often a breakup is preceded by a loss of control and substantial increase in airspeed. An inadvertent increase in airspeed makes structural overload and breakup of an airplane much more likely.

None of the accidents described above appear to have involved excessive speed, a loss of control, or severe weather conditions. The review of design and certification data for these airplanes indicates that the assumed aerodynamic loading of the wings was reasonable, and the designer provided evidence that the airplane wing structure successfully underwent structural tests in excess of the certification requirements. Additionally, CZAW performed 14 structural tests of the Zodiac CH-601XL airplane structure, based on its own load analysis.[9] However, 1 of the 14 tests indicated that the strength of the wings might be slightly below the ultimate load levels required to meet ASTM certification standards.

Thus far, the Safety Board's review indicates that the wing structure can sustain loads in excess of the design limit loads (+4 Gs) but may fall short of the design ultimate load (+6 G) requirement by a small amount. At this time, Board engineers believe that the wing structure meets the intent of the certification requirements and that, absent flutter, it will not fail in normal flight up to limit load. The Board does not believe the overall structural capability of the CH-601XL played a role in the in-flight breakups discussed in this letter. However, the Board is concerned that the Dutch investigative and certification authorities question whether Zodiac airplanes meet the structural certification requirements for ultimate load and anticipates that the FAA will consult with them to understand the differences in their evaluations of the structural capability of the Zodiac CH-601XL.

**Aerodynamic Flutter**

Aerodynamic flutter is a type of dynamic aeroelasticity that occurs when aerodynamic and structural forces interact in such a way that energy from the airflow around an airplane gives rise to an unsafe structural vibration in the airplane. These vibrations can quickly lead to

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[8] The tests were supervised by the Light Aircraft Association of the Czech Republic, Civil Aviation Authority of the Czech Republic, and Deutscher Aeroclub, E.V. The loads applied in the tests were based on a load analysis prepared by CZAW for the Zodiac XL.

[9] The Czech aeronautical authorities and a representative of Deutscher Aeroclub E.V. oversaw the tests.

structural failure if not sufficiently damped. Bending stiffness, torsional stiffness, and the mass of the wing and aileron define the natural frequency of the structure and the critical speed at which flutter may develop. Whether wing or aileron flutter develops and continues also depends on the mass distribution of the ailerons. Mass-balanced[10] ailerons greatly decrease susceptibility to flutter as they are less likely to deflect because of dynamic bending or twisting of the wing.

The Safety Board notes that, unlike S-LSA, normal, utility, acrobatic, and commuter category airplanes are certified under the provisions of 14 CFR 23.629 and Advisory Circular (AC) 23.629-1B, "Means of Compliance with 14 CFR 23.629, Flutter" and typically incorporate a combination of structural stiffness and mass-balanced flight controls.

*CH-601XL Susceptibility to Flutter*

As noted above, S-LSA are not required to meet the certification standards of Section 23.629. Nonetheless, many S-LSA designs do incorporate mass-balancing as an effective means of protection against flutter. The CH-601XL does not provide for mass-balanced ailerons and, instead, relies primarily on control cable tension as a protection from flutter. Tension in the control cables adds stiffness to the aileron system, provides for a higher natural frequency of the aileron/wing combination, and raises the airspeed at which flutter may occur. However, cable tension alone does not provide the more direct protection afforded by mass-balanced flight controls.

There is substantial circumstantial evidence that flutter occurred in some, if not all, of the above-cited accidents. Flutter often does not leave definitive signatures, but several eyewitness accounts of the accidents are consistent with the occurrence of flutter. For example, witnesses of the February 2006 Oakdale, California, accident said that the wings of the accident airplane "visibly vibrated" and the left wing collapsed upward and folded rearward against the fuselage as the airplane entered the traffic pattern to the airport. Visible vibration of the wing is consistent with flutter, especially given the minimal speed and maneuvering normally experienced when entering the 45° entry leg of a traffic pattern. Witnesses of the February 2008 accident in Barcelona, Spain, also reported vibration of the wings, which is again consistent with flutter. During the April 2008 Polk City, Florida, accident, a witness observed that the airplane banked slightly left, then slightly right, then significantly left and right, before suddenly yawing right with the right wing folded up.[11] Roll commands through the stick to the ailerons are unlikely to cause structural failure of the wing. However, uncommanded aileron movement consistent with flutter and resultant wing twisting could account for the described motion of the airplane.

Although there were no witnesses to the November 2006 Yuba City, California, accident, the radar data show a relatively slow speed and subsequent climb. The airplane appears to have suddenly descended before accelerating. It is likely that the airplane broke up at the start of the descent even though the airspeeds at the top of the descent appeared relatively low. Such a scenario is consistent with flutter.

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[10] A flight control pivots about its hinge line (or flexure point for hingeless ailerons), and the structure and mass are generally aft of the hinge line. For mass balancing, mass is added in front of the hinge line to balance the flight control.

[11] No evidence was available to determine if the owner of the accident airplane had checked the tension of the airplane's control cables prior to the accident flight.

Similarly, there were no witnesses to the March 3, 2009, accident at Antelope Island, Utah. However, radar data show no maneuvers that would suggest an increase in airspeed that could lead to a structural overload or flutter as a result of overspeed. In fact, radar data show that the airspeed before the accident was about 112 KCAS, well below the airplane's never-exceed speed of 140 KCAS. As noted above, the builder stated that he used a tensionmeter to set the cable tensions and checked the tensions 6 flight hours before the accident. Turbulence, which can initiate flutter, had been reported in the vicinity, suggesting that flutter is a distinct possibility even though the cables were apparently properly tensioned.

In addition to the above accidents, incidents of flutter have been reported by several CH-601XL pilots. In a case that was discussed in a Zenair newsletter dated July 25, 2008, an airplane was making its first flight when the pilot encountered flutter. Upon a successful landing, the pilot found that the aileron cables were not set to the proper tension of 30 pounds (lbs). Once properly tensioned, the airplane has been flown repeatedly with no further occurrence of flutter. In another case reported to the Zodiac Builders Analysis Group (ZBAG)[12] on June 15, 2008, a pilot was flying straight and level at 110 knots indicated airspeed (KIAS)[13] when he experienced a wing vibration that seemed to be intensifying. He reacted quickly by reducing throttle and simultaneously turning left and pulling up to reduce airspeed. The flutter stopped. He repeated the scenario with the same results. On the ground, the pilot noted that the aileron cables were loose and that he had omitted the flap stops. Both of these problems were corrected, and he was unable to recreate the events in future flights. On November 17, 2008, yet another pilot reported to a web-based Zodiac users' group forum[14] that he experienced a flutter event several years ago. He recently bought a tensionmeter and found that his aileron cables were at 17 lbs of tension.

In addition to the incidents of low aileron cable tension reported by pilots, a November 2008 survey of CH-601XLs conducted by Zenair found that 12 of the 14 airplanes examined had cables that did not meet the factory-specified tolerances. As noted above, because the ailerons on these airplanes are not mass-balanced, they are particularly susceptible to flutter if the cable tension is not adequate.

Moreover, on August 11, 2008, AMD notified CH-601XL airplane owners of a recent flutter event attributed to loose aileron control cables and instructed them to ensure the tension of their airplanes' flight control cables were within 5 lbs of the specified values for rudder (22 lbs), aileron (30 lbs), and elevator (40 lbs) cable tension. On October 28, 2008, Zenair's European division issued a service bulletin noting that "loose control cables can lead to flutter of control surfaces" and that flutter had "been experienced in the Zodiac CH-601XL airplane as reported by two pilots." The bulletin instructed owners to inspect all control cables and adjust them as necessary to maintain the specified tension values.

Zenair asserted in correspondence with the Safety Board that proper cable tension is an adequate strategy to protect against flutter for this airplane type and further asserted that November 2005 certification flight tests confirmed the airplane is adequately protected from

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[12] The ZBAG was created by an airplane builder to investigate and fund research into the in-flight breakups of Zodiac CH-601XL airplanes.

[13] KIAS is the speed of the airplane as shown on the airspeed indicator on the cockpit instrument panel.

[14] This forum was accessed online at <www.matronics.com/listbrowse/zenith601-list/index.html>.

flutter. In those certification flight tests, the control stick was rapped with a mallet or stick to attempt to induce flutter. The stick vibrations quickly subsided and the designer concluded the system was well damped. However, there are multiple modes (or types) of flutter; and, according to other airplane designers and the FAA, this testing method alone may not be adequate to uncover susceptibility to flutter in all its modes.

Further, a ZBAG engineer modeled the structure and flutter characteristics of the Zodiac CH-601XL and has expressed concern to Safety Board investigators that cable tension alone, even if correct, may not provide adequate flutter protection.[15] The modeling is somewhat limited because there was no ground vibration test of the airframe, which would have provided additional data to refine the analytical model so that it would represent the airplane more accurately. However, even without these data, the model appears to be sufficient to identify concerns regarding flutter. The model indicates that flutter may be possible in the speed ranges in which CH-601XLs are certificated to operate. The model also indicates that mass balancing the ailerons would provide significant protection from flutter.

The Safety Board notes that the effects of flutter are often catastrophic, that flutter is apparently common in these airplanes, and that the control cables of these airplanes have often been found to be loose, leaving the airplanes with no protection from flutter. Further, the ZBAG engineer's modeling results indicate that, even if the cables were always properly tensioned, flutter may still occur. The Antelope Island, Utah, accident also raises serious questions about the adequacy of cable tension alone to prevent flutter, as the flight control cables were likely correctly tensioned at the time of the accident. The Board is concerned that simply maintaining proper cable tension on CH-601XLs is not adequate protection from flutter. Mass-balanced ailerons provide a more direct protection from flutter than do properly tensioned control cables and would continue to provide protection even without adequate control cable tension. Although Zenair continues to assert that maintaining proper cable tension alone provides adequate flutter protection, the most recent accident indicates otherwise. The Board notes that this airplane series has already been grounded in two countries (the Netherlands on October 24, 2008, and the United Kingdom on November 4, 2008) because of concerns about in-flight structural breakups.

The Safety Board recommended that the FAA prohibit further flight of the CH-601XL until such time that the FAA determines the CH-601XL has adequate protection from flutter. The Safety Board further recommended that the FAA require a comprehensive evaluation of the wing and aileron system on the CH-601XL, including ground vibration tests, to identify design and/or operational changes that will reduce the potential for flutter; the evaluation should give significant consideration to the benefits of installing mass-balanced ailerons and should also address the adequacy of cable tension values specified by Zenair. Finally, the Safety Board recommended that the FAA notify owners of CH-601XL airplanes of the design and/or operational changes to the CH-601XL that are identified as necessary following their evaluation and require the owners of CH-601XL airplanes to implement those changes.

[15] The engineer used a sophisticated computer program (NASTRAN) to model the structure and flutter characteristics of the Zodiac CH-601XL.

*ASTM Standards Addressing Flutter for Light Sport Airplanes*

Based on pilot reports and Zenair's cable tension survey, it appears that a high percentage of these airplanes are operating with loose control cables and that this condition apparently contributed to previous instances of flutter. Further, the Safety Board notes that Zenair, AMD, and CZAW have specified the required cable tension values and instructed owners to ensure that proper tensioning is maintained using a calibrated tensionmeter. However, the Safety Board has learned that those specified tension values are higher than values previously specified by the designers and that the new values were based on tests of a CH-2000 airplane, not a CH-601XL, calling into question the engineering basis for those values.

The ASTM standards under which light sport airplanes such as the Zodiac airplanes are designed and manufactured provide designers with limited guidance regarding protection from flutter. Paragraph 4.6 of the standards cites only flight-testing as a method for evaluating for flutter.[16] The standards do not require the designer to provide for redundant protection from flutter or to perform adequate testing and modeling to determine that such redundant protection is not necessary. Moreover, the builders, owners, and pilots were not provided specific information about control cable tensions until 2006.

In contrast, the FAA has provided extensive guidance for the mitigation of flutter to designers of 14 CFR Part 23 airplanes through AC 23.629-1B. The Safety Board recognizes that full compliance with the guidance found in AC 23.629-1B is not required for light sport airplanes to achieve adequate protection; however additional guidance in ASTM F-2245 is necessary. The Safety Board concludes that the guidance in the ASTM standards is likely not sufficient for the Zodiac CH-601XL because the airplane's design incorporates limited and inadequate flutter mitigation strategies, as evidenced by the in-flight breakups that were likely the result of aileron flutter.[17] Therefore, the Safety Board believes that ASTM International should incorporate additional requirements into the standards for light sport airplanes that provide for additional flutter mitigation strategies.

**Potential Role of Stick Forces**

In an effort to identify potential factors that might have contributed to the many in-flight breakups of CH-601XL airplanes, and mindful of the fact that high loads can cause structural failure, the Safety Board examined the control stick forces required to generate high maneuver loads[18] on the accident airplane model. Zenair provided the Safety Board with a flight test report

[16] ASTM F2245-07a5 4.6 *Vibrations*—Flight testing shall not reveal, by pilot observation, heavy buffeting (except as associated with a stall), excessive airframe or control vibrations, flutter (with proper attempts to induce it), or control divergence, at any speed from $V_{s0}$ to $V_{df.}$ The speed range is from the flaps down stall speed ($V_{s0}$) to the demonstrated dive speed, $V_{df}$, where $V_{ne}$ [never-exceed speed] is less than or equal to 0.9 $V_{df}$.

[17] The Safety Board notes that in response to the FAA's 2002 notice of proposed rulemaking regarding certification of light sport airplanes, the Board stated it was concerned that unless the FAA periodically reviewed and approved the industry consensus standards, its oversight and control of these requirements as they evolved would become uncertain. The Board also suggested that the FAA ensure reviews occurred frequently in the initial stages of the proposed rule's implementation.

[18] Maneuver loads are aerodynamic loads imposed on an airplane (referred to as G) as a result of flight control inputs or maneuvering flight, such as dives, loops, and turns.

that had been used to validate the airplane design under ASTM standards. The report included data on the stick forces required to generate maneuver loads or Gs.[19] The term "stick force per G" refers to the control force gradient that is derived from flight test data. Data from the Comparative Aircraft Flight Efficiency Foundation's[20] airplane performance reports show that the stick force per G on other airplanes is similar to that of the Zodiac CH-601XL except that, on the CH-601XL, the stick-force gradient lessens distinctly as loads increase above 2.5 Gs.[21] The lessening of the gradient continues as loads surpass 4 Gs. As a result, at high Gs, a moderate increase in stick force could result in larger than expected increase in maneuver loads.

A sufficient stick-force gradient is required for pilots to maneuver an airplane safely. The Safety Board recognizes that experimental and light sport airplanes typically exhibit lighter stick forces than airplanes certified under 14 CFR Part 23 and that, if properly trained, pilots can safely maneuver airplanes with relatively shallow gradients. However, even experienced pilots may find control difficult if the gradient is not constant but instead lessens as Gs increase. With a lessening stick-force gradient, it becomes easier to inadvertently overcontrol the airplane and reach higher acceleration forces than intended.

Zenair has expressed concern that pilots may be overcontrolling the airplane with large or aggressive stick movements. On May 10, 2007, the designer wrote the owners and pilots of Zodiac airplanes an advisory letter, which included the following:

> The Zodiac aircraft has a large amount of elevator control. ... Pushing the stick rapidly full forward at cruise speed—even briefly—can result in serious damage to the airframe. Caution must be exercised to not inadvertently push the stick rapidly to its limits (i.e. while stretching, reaching into the rear baggage compartment, etc.).

In July 2007, the designer issued the following update:

> Owners should take note that the CH-601XL has relatively light pitch control forces and that it is possible to exceed the positive (+6) and the negative (-3) ultimate load factors if forcing the controls in a very rough or sudden manner.

Pilots usually become familiar with the maneuvering characteristics of an airplane while operating routinely between the 1 G and 1.5 Gs common during normal flight. Higher G forces are often disconcerting, and a lessening of the stick-force gradient may go unnoticed. In addition, the stick forces are least when operating at the maximum aft center of gravity. Although the Zodiac designer has advised pilots of the light stick forces, the Safety Board concludes that pilots may not be aware of the change in the effect of stick forces that occurs while maneuvering at higher Gs. The Safety Board recommended that the FAA should evaluate the stick-force gradient

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[19] Stick force per G is a gradient. One G is the flight load experienced as the airplane is flown straight and level (not maneuvering).

[20] The Comparative Aircraft Flight Efficiency Foundation is a non-profit organization that provides flight test reports for experimental airplanes.

[21] The Zodiac designer also provided flight test data for the CH-600/601 (non-XL) airplanes. The data show that the stick forces are generally somewhat lighter than those experienced on the CH-601XL but that the gradients are constant until the airplane reaches at least 4 Gs.

of the CH-601XL airplane at the maximum aft center of gravity and notify pilots of the stick-force gradient that occurs at the aft center of gravity, especially at the higher G forces. In addition, the Safety Board believes that ASTM International should incorporate additional requirements into the standards for light sport airplanes that provide for stick-force characteristics that will minimize the possibility of pilots inadvertently overcontrolling the airplane.

**Airspeed Correlations**

Although there is no evidence that airspeed correlations between indicated airspeed (IAS) and calibrated airspeed (CAS) contributed to any of the accidents cited above, during its investigations, the Safety Board found errors in the correlations that were provided by Zenair and AMD. In addition, the Safety Board found significant differences in the airspeed correlation data provided by Zenair, AMD, and CZAW.

To establish an accurate airspeed correction table to correlate IAS and CAS, CAS must be established first. However, Zenair chose to determine true airspeed (TAS)[22] and compare TAS directly with IAS. AMD also used a similar technique in correlating airspeed for its airplanes. TAS was determined by using a global positioning system (GPS) and flying directly into and with the wind. The average GPS values provided a TAS. AMD reported that it also sometimes used a radar gun to establish TAS. Those methods would be adequate if the atmospheric conditions for the test flight were those of standard sea level. (Standard temperature is 15° Celsius [C].) However, for the Zenair flight tests, the pressure altitude was 1,000 feet and the temperature was 31° C. The original flight test data were not corrected for these nonstandard atmospheric conditions. As a result, the airspeed correlations provided by Zenair contain substantial error. Further, the atmospheric conditions and resultant airspeed correlation results for the AMD flight tests would change on a daily basis. Errors in airspeed correlation data would result in incorrect airspeed data in the pilot operating handbook (POH) and may result in a pilot inadvertently flying at unsafe airspeeds.

Safety Board engineers used the altitude and temperature recorded on the Zenair flight test data sheets to calculate CAS to more accurately determine the correlation to IAS and to compare those results with data provided by CZAW. CZAW provided airspeed correlation data that were obtained using a trailing probe technique to establish CAS, which was then compared directly to the IAS in the airplane. That technique is an accepted method to directly establish the correlation between CAS and IAS. CZAW representatives stated that they installed the static ports as defined in the drawings provided by Zenair, so the airspeed correlation data provided by Zenair, AMD, and CZAW should be the same or similar. However, the CAS-IAS corrections provided by Zenair and CZAW have opposite signs. The differences between the data provided by the companies cannot be explained from the available data or by discussions with the companies' representatives. The Safety Board concludes that the airspeed correlations of CAS and IAS for the Zodiac CH-601XL provided by Zenair and CZAW are not correct in the case of at least one of the companies.

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[22] IAS is the airspeed shown on the airplane's airspeed indicator. TAS is the speed of an airplane relative to the air mass in which it flies. CAS is obtained by correcting TAS for atmospheric pressure, temperature, and compressibility.

In addition, various photos of airspeed indicators and copies of POHs show that the airspeed information is not consistent. Therefore, the Safety Board recommended that the FAA determine the correct airspeed correlation between CAS and IAS for the CH-601XL, require that the correct data be included in existing and new airplane POHs, and ensure that the information on the airspeed indicator is accurate and consistent with the POHs.

A representative of Zenair noted that Section 9.1 of the ASTM standards requires only that all flight speeds be presented as CAS in the POHs of S-LSA but that IAS is not required to be included. Thus, Zenair only provided CAS data and separately provided a conversion table that the pilot or owner could use to fill in the blanks of the POH for IAS. This approach has led to confusion and incorrect information being entered into POHs. To avoid such errors, it is imperative that CH-601XL pilots be provided both CAS and IAS information in the POH that is consistent from airplane to airplane and in a format that is easy to understand. The Safety Board concludes that the ASTM standards are not sufficient to ensure adequate determination of airspeed correlation data. In addition, the ASTM standards do not require that both CAS and IAS data be included in POHs. Therefore, the Safety Board believes that ASTM International should incorporate additional requirements into the standards for light sport airplanes that provide for the accurate determination of airspeed data and for the adequate presentation of that data in existing and new airplane POHs and on airspeed indicators.

Therefore, the National Transportation Safety Board recommends that ASTM International:

> Incorporate additional requirements into the standards for light sport airplanes that provide for additional flutter mitigation strategies. (A-09-38)
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> Incorporate additional requirements into the standards for light sport airplanes that provide for stick-force characteristics that will minimize the possibility of pilots inadvertently overcontrolling the airplane. (A-09-39)
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> Incorporate additional requirements into the standards for light sport airplanes that provide for the accurate determination of airspeed data and for the adequate presentation of that data in existing and new airplane pilot operating handbooks and on airspeed indicators. (A-09-40)

The Safety Board has also issued recommendations to the FAA. In response to the recommendations in this letter, please refer to Safety Recommendations A-09-38 through -40. If you would like to submit your response electronically rather than in hard copy, you may send it to the following e-mail address: correspondence@ntsb.gov. If your response includes attachments that exceed 5 megabytes, please e-mail us asking for instructions on how to use our Tumbleweed secure mailbox procedures. To avoid confusion, please use only one method of submission (that is, do not submit both an electronic copy and a hard copy of the same response letter).

Acting Chairman ROSENKER and Members HERSMAN, HIGGINS, and SUMWALT concurred with these recommendations.

*[Original Signed]*

By: Mark V. Rosenker
Acting Chairman